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CHARACTERIZATION AND DIVERSITY OF THE MARKET-GARDENING PRODUCTION SYSTEMS AND THEIR INTERACTIONS WITH URBAN AND PERI-URBAN ENVIRONMENT IN SOUTHERN-BENIN, WEST AFRICA.

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ABSTRACT
The market-gardening production plays an important role in contribution to food availability. However this activity is limited by constraints and also generates harmful effects on health and environment. Thus to ensure the sustainability of this activity is a great challenge. A survey on market-gardening farms management was carried out from 2009 to 2010 on 197 farmers in production site of Cotonou, Sèmè-kpodji and Ouidah in Southern Benin. The aim of study was to characterize and categorize the farms in order to identify the means by which this activity could be improved and made socially, economically and ecologically more sustainable. The production was characterized by a weakness of farming rotations, the use of chemical and organic fertilizers as well as the use of chemical pesticides in the pest and disease control. Farmers' annual earning varied widely with an average of 917,646 XOF. About one quarter of the farmers earn less than the minimum wage. By combining Multiple Correspondence Analysis (MCA) and Hierarchical Cluster Analysis (HCA), we identified seven types of farmers. Development Project focusing on sustainability improvement of the production and income of the producers could target the first five categories of market-gardeners who experience more hardship (difficult access to land, challenges with irrigation and pests and diseases control). These farms depend mostly on chemical pesticide. Authorities especially at the municipal level should help with a better land allocation, particularly for farmers in Cotonou and Sèmè-kpodji. Continuing education and awareness raising efforts by Extension services towards producers about health and environmental hazards of synthetic pesticides could improve sustainability of vegetable growing in Southern-Benin.

KEYWORDS : Vegetable production, sustainability, typology, income, urban environment, Benin

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INTRODUCTION

Agriculture constitutes the base of the economy for Africa sub-Saharan countries. It contributed between 29.9% and 33.2% of the Gross domestic product (GDP) of the West and Central African countries from 1985 to 1999 (FIDA, 2001). In Benin, agriculture's weight in to the GDP evolved from 34% in 1995 to 32.6% in 2005 then to 29.89% in 2008, that is an average of 34.3% from 1995 to 2005 and 30.48% from 2005 to 2008 (Aly *et al*., 2007 ; PSRSA, 2009). It made an average contribution of 0.9% to the economic growth between 2007 and 2009 (SCRP 2007-2009).

Urban and periurban agriculture contribute to food safety in African countries cities where rural migration is significant (Mwangi *et al.*, 1995 ;Cofie *et al.*, 2003). Market-gardening is an important branch of urban and periurban agriculture. It contributes significantly to jobs creation in Benin (PADAP, 2003).

Several systems of production exist in market-gardening. The two mains systems are conventional production systems (using pesticides and chemical fertilizers) and the biological production systems. The Conventional system is more widespread in vegetable growing (Akogbéto *et al.*, 2005 ;Ahouangninou *et al.*, 2011). Production is done on small-size farms in large cities or in their suburbs. Farmers often occupy marshes areas for production with limited resources. Their small harvests rarely allow them to improve their economic and social standing. The activity generates important harmful effects: biodiversity reduction and human health issues in relation with the use of chemical pesticides. Such effects are called the negative externalities of the production because they generate costs which are usually not incorporated to the market prices (Dobbs and Pretty, 2004 ; Pretty *et al.*, 2011). A recent study in rural area in Southern Benin, indicated the presence of pesticides residues in vegetable samples taken just before harvest (Ahouangninou *et al.*, 2012). Since it cannot be any sustainable local development without sustainable income-generating activities within the communities; it is important for public authorities and local government officials to become more knowledgeable about market-gardening in order to include it in communal development programs to ensure the sustainability of the natural resources used in production. Because each farmer has a unique way of combining resources and managing his farm, there are as many production systems as they are farms. (De Bon, 2001 ;Tittonell *et al.*, 2005). As it is not possible to formulate individualized policies, it is necessary to categorize the farms based on their common characteristics (Abdulkadir *et al.*, 2012). To classify the farms in homogeneous categories, the multivariate analysis methods are the most widely used (Lazard *et al.*, 2009 ; Sanogo *et al.*, 2010 ; Joffre et Bosma, 2009 ; Tittonnel *et al.*, 2010 ; Abdulkadir *et al.*, 2012).

The main objective of this study was to characterize and make a typology of the market-gardening farms in three communes of southern Benin in terms of their income, their resources endowment, their structure and their modes of operation in order to identify means of social, economic and environmental improvements.

METHODOLOGY

Study area

The study was conducted in the market-gardening exploitations in urban and periurban area in three communes of Southern-Benin: Houéyiho in Cotonou, Sèmè-kpodji and Ouidah (Figure 1). They belong to two agro-ecological areas: the littoral zone (Sèmè-kpodji) and the intra-urban zone (Houéyiho and Ouidah). Temperatures in these three communes vary between 24° and 31°. The climate is subequatorial, characterized by two dry seasons and two rainy seasons. The average annual rainfall varies from 950 mm to 1500 mm. In the three communes, vegetable growing is a key economic activity that supplies fresh food to the populations.

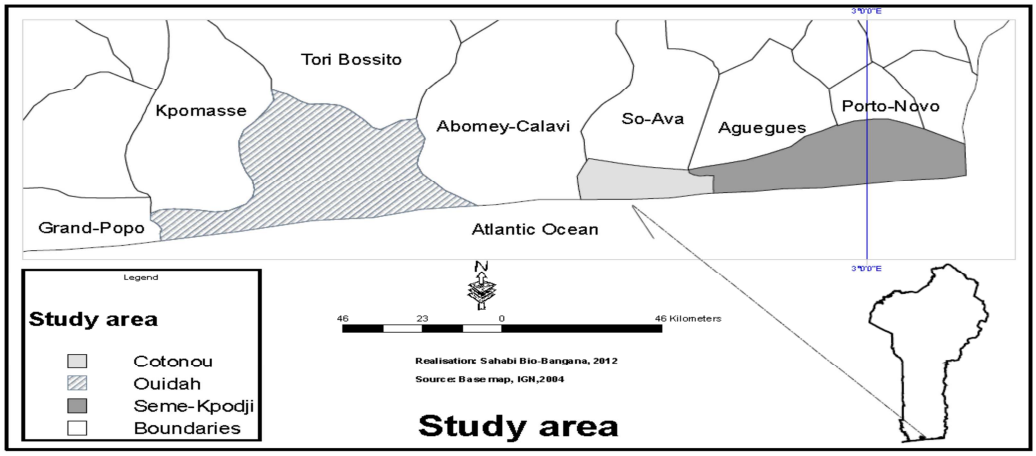

Figure 1. Study area

Selection of study farms and statistical analysis

A cross-sectional study was conducted from Décembre 2009 to May 2010 with 197 randomly selected farmers. Overall 105 farmers in Cotonou, 48 in Sèmè-kpodji and 44 in Ouidah were included in this study. We interviewed these farmers and filled the questionnaires. The data collected covered socio-demographic information, sources of income, the management of their exploitations, husbandries, quantities of inputs, volumes of harvests, marketing systems, and the costs and the incomes resulting from the 2009 production. Descriptive statistics were done with the software Excel 2007. The SPAD 5.5 software was used for the multiple correspondence analysis (MCA) and the hierarchical cluster analysis for a proper classification of the farms.

Multiple correspondence analysis was used to identify both the similarities and distinctive factors of the market-gardening exploitations, in term of main characteristics, farmers' behaviors, production methods and income.

This method was able to emphasize the multiple bonds existing between the variables and even covered factors occulted by the descriptive analysis. The hierarchical cluster analysis was used to identify clusters of producers.

RESULTS

Sociodemographic characteristics of farmers

The farmers included in this study were between 17 and 77 years old (Table 1). One third of the farmers (33.0%) were less than 30. About 59.4% had an age ranging between 31 and 60 years old. The average age was 36.7 (Table 2).

Table 1.Sociodemographic characteristics of the producers

	Houéyiho (N=105)		Sèmè-kpodji (N=48)		Ouidah (N=44)		Total (N=197)	
	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Age (years)								
17-30	34.3	36	33.3	16	29.5	13	33.0	65
31-60	56.2	59	66.7	32	59.1	26	59.4	117
61 and more	9.5	10	0.0	0	11.4	5	7.6	15
Education level								
Not educated	15.2	16	29.2	14	20.4	9	19.8	39
Primary school	41.9	44	43.8	21	43.2	19	42.6	84
Secondary school	40.0	42	20.8	10	34.1	15	34.0	67
University	2.9	3	6.2	3	2.3	1	3.6	7
Gender								
Males	87.6	92	85.4	41	84.1	37	86.3	170
Females	12.4	13	14.6	7	15.9	7	13.7	27
Marital status								
Single	24.8	26	16.7	8	6.8	3	18.8	37
Married	75.2	79	83.3	40	90.9	40	80.7	159
Widowed	0.0	0	0.0	0	2.3	1	0.5	1
Principal activity								
Yes	86.7	91	89.6	43	81.8	36	86.3	170
No	13.3	14	10.4	5	18.2	8	13.7	27
Experience (years)								
1-5	15.2	16	45.8	22	25.0	11	24.9	49
6-14	29.5	31	16.7	8	38.6	17	28.4	56
15 and more	55.2	58	37.5	18	36.4	16	46.7	92

The average age of farmers in Sèmè-kpodji (34.4 years) was lower than those in Houéyiho (37.9 years) and those in Ouidah (36.4 years). The majority of producers were male (86.3%). About 1/5 of them never attended school, 2/5 got basic primary education and 1/3 reached the secondary level. The majority of farmers (86.7%) had gardening as their main income-generating activity. About half (49.8%) of respondents had this activity as their only job. Regarding their work experience in farming, 24.9% reported 1 to 5 years of experience; 28.4% had between 6 and 14 years of experience. About half (46.7%) had more than 15 years of experience. The

average experience was 14.36 years. The farmers of Houéyiho (in Cotonou) were in average more experienced than their peers of Sèmè-kpodji and Ouidah (p=0.0001).

Table 2. Averages and standard deviation of the variables

	Houéyiho		Sèmè-kpodji		Ouidah		Total		
	Mean	Standard dev	Mean	Standard dev	Mean	Standard dev	Mean	Standard dev	p-value
Farmer characteristics									
Age (years)	37.86	13.64	34.40	9.64	36.43	12.52	36.70	12.55	0.5551
Experience (years)	17.23	10.60	10.83	10.49	11.34	6.89	14.36	10.29	0.0001
Area (m^2)	603.75	460.66	2478.75	2941.61	1861.64	2290.38	1341.55	2001.87	0.0001
Inputs quantity									
Urea (kg/year)	182.72	255.62	448.87	677.60	353.92	364.12	285.81	382.67	0.002
NPK (kg/year)	132.14	255.35	592.66	1025.52	107.00	114.04	238.73	411.44	0.0001
Poultry droppings (kg/year)	3367.48	-	6008.10	-	4744.20	-	4318.37	-	0.0001
Compost (kg/year)	2147.29	-	9737.50	-	933.33	-	3725.53	-	0.0001
Water (l/day)	4505.71	2655.21	12652.08	5894.03	11809.30	5672.71	8121.87	4118.32	0.0001
Fuel (l/week)	12.96	-	12.58	-	18.28	-	13.25	6.18	0.001
Cost and Result									
Pesticide cost (Fcfa/year)	42381	24111	92532	47443	76682	48804	62107	42974	0.0001
Earnings (XOF/year)	552129	477851	1388831	882336	1275883	1132589	917646	862567	0.0001

Farming techniques and pests control methods

The plots sizes generally varied between 5 and 12 square meters. Their average size was 7 square meters. Most of the market-gardeners used hoes and rakes to make plots.

For fertilization, almost all the farmers used chemical fertilizers (99.5%) and organic manures, especially the poultry manure (100%) (Table 3).

Table 3. Frequency of use of fertilizers and fossil energies

	Houéyiho (N=105)		Sèmè-kpodji (N=48)		Ouidah (N=44)		Total (N=197)	
	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Urea	100.0	105	97.9	47	100.0	44	99.5	196
NPK	93.3	98	95.8	46	95.4	42	94.4	186
Poultry droppings	100.0	105	100.0	48	100.0	44	100.0	197
Compost	28.6	30	8.3	4	6.8	3	18.8	37
Fuel	25.7	27	85.4	41	15.9	7	38.1	75

The average quantities of NPK, urea, poultry manure and compost used during 2009 by these farmers were of 238.73 kg; 285.81 kg; 4318.37 kg and 3725.53 kg respectively (Table 2). The average amounts of mineral fertilizer (urea) and organic fertilizer (poultry manure) used to grow *Solanum macrocarpon* were 333.33 Kg/ha and 16.08 t/ha respectively.

To control pests and diseases, farmers used chemical pesticides (99.5%) (Table 4). Some of them combined the chemical pesticides with bio-pesticides to produce tomato and *Solanum macrocarpon.*

Table 4. Characteristics of the market-gardening exploitations

	Houéyiho (N=105)		Sèmè-kpodji (N=48)		Ouidah (N=44)		Total (N=197)	
	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Area (m²)								
<500	46.7	49	0.0	0	20.4	9	29.4	58
[500, 1000[	39.0	41	20.8	10	25.0	11	31.5	62
[1000, 3000[	13.3	14	66.7	32	34.1	15	31.0	61
>3000	1.0	1	12.5	6	20.4	9	8.1	16
Land ownership								
Public land	100.0	105	97.9	47	4.5	2	78.2	154
Renting	0.0	0	2.1	1	38.6	17	9.1	18
Family's land	0.0	0	0.0	0	2.3	1	0.5	1
Personal	0.0	0	0.0	0	54.5	24	12.2	24
Labor								
Family	45.7	48	66.7	32	36.4	16	48.7	96
Temporary	47.6	50	20.8	10	61.3	27	44.2	87
Full time	13.3	14	18.7	9	9.1	4	13.7	27
Irrigation system								
Watering can	74.3	78	14.6	7	84.1	37	61.9	122
Motor-driven pump and pipe	16.2	17	81.2	39	15.9	7	32.0	63
Motor-driven pump and swivel	9.5	10	4.2	2	0.0	0	6.1	12
Source of water								
Wells	38.1	40	0.0	0	31.8	14	27.4	54
Shallows	40.0	42	0.0	0	65.9	29	36.0	71
Drillings	21.9	23	100.0	48	2.3	1	36.5	72
Farming rotation								
Yes	50.5	53	58.3	28	9.1	4	43.1	85
No	49.5	52	41.7	20	90.9	40	56.9	112
Chemical pesticide use								
Yes	100.0	105	97.9	47	100.0	44	99.5	196
No	0.0	0	2.1	1	0.0	0	0.0	1

Spendings on pesticides in 2009 rose on average to 62,107 XOF (124 USD based on a 500/1 exchange rate) per farmer. These expenditures amounted to 42,381 XOF (85 USD), 92,532 XOF (185 USD) and 76,682 XOF (153 USD) in Houéyiho, Sèmè-kpodji and Ouidah respectively (Table 2). Approximately 43.5% of the farmers implemented farming rotation. This technique was most common in Houéyiho and Sèmè-kpodji.The main sources of water used to irrigate the fields were water taken from wells (27.4%), rainwater from shallows (36%) and groundwater (36.5%) (Table 4). Most of the farmers (61.9%) used watering cans to sprinkle the plants. Some of them (32%) used a motorized pump and sprinkler pipes. The others (6.1%) used a motorized pump and swivel system. The motorized systems of irrigation dominated in Sèmè-kpodji. The average daily volume of water consumed was 8,121.87 Liters (L) per farmer. It was significantly higher in Sèmè-kpodji compared to Houéyiho and Ouidah (p=0.0001). For farmers using the motorized systems of irrigation, the average weekly volume of gasoline used was of 13.25 L per farmer (Table 2). There was a significant variation between diverse production sites (p=0.001). The average volumes of gasoline consumed were significantly higher in Ouidah.

Distribution of the vegetables produced and incomes

Several vegetable species were grown in Houéyiho, Sèmè-kpodji and Ouidah (Table 5). The most grown vegetables are solanum (*Solanum macrocarpon*), amaranth (*Amaranthus hybridus*), vernonia (*Vernonia amygdalina*), tomato (*Lycopersicon esculentum*), lettuce (*Lactuca sativa*), carrot (*Daucus carota*), cucumber (*Cucumis sativus*) and cabbage (*Brassica oleracea*).

Table 5. Vegetables speculations production Frequency

	Houéyiho (N=105)		Sèmè-kpodji (N=48)		Ouidah (N=44)		Total (N=197)	
	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Solanum	79.0	83	75.0	36	95.4	42	81.7	161
Celosy	7.6	8	6.2	3	4.5	2	6.6	13
Amaranthe	72.4	76	70.8	34	72.7	32	72.1	142
Vernonie	46.7	49	29.2	14	20.4	9	36.5	72
Coriandre	1.9	2	0.0	0	0.0	0	1.0	2
Celery	1.0	1	0.0	0	2.3	1	1.0	2
Crin-crin	1.0	1	2.1	1	0.0	0	1.0	2
Tomato	11.4	12	52.1	25	13.6	6	21.8	43
Pepper	1.9	2	22.9	11	0.0	0	6.6	13
Sweet pepper	11.4	12	20.8	10	15.9	7	14.7	29
Onion	10.5	11	14.6	7	4.5	2	10.2	20
Eggplant	0.0	0	2.1	1	0.0	0	0.5	1
French bean	3.8	4	2.1	1	0.0	0	2.5	5
Cucumber	23.8	25	52.1	25	18.2	8	29.4	58
Cabbage	26.7	28	31.2	15	25.0	11	27.4	54
Parsley	4.8	5	2.1	1	6.8	3	4.6	9
Basil	6.7	7	16.7	8	6.8	3	9.1	18
Turnip	3.8	4	10.4	5	0.0	0	4.6	9
Mint	1.9	2	2.1	1	0.0	0	1.5	3
Bissape	1.9	2	2.1	1	0.0	0	1.5	3
Beet	0.0	0	2.1	1	0.0	0	0.5	1
Water melon	0.0	0	4.1	2	11.4	5	3.6	7
Carrot	52.4	55	75.0	36	9.1	4	48.2	95
Lettuce	82.8	87	41.7	20	47.7	21	65.0	128

Generally farmers sold their production to the retailers who came to supply themselves directly on the production areas. Some (2.53%) sold their products to restaurants. The average return on investment was 42.64%, thus 100 XOF of initial investment generated a profit of 42.64 XOF. It was higher in Sèmè-kpodji (48.69%) compared to Houéyiho (40.85%) and Ouidah (40.34%). No correlation between profitability and farms size was observed. The average earning of the production per annum per farmer was 917,646 XOF (1,835 USD) in 2009 without their own consumption and losses estimated at 45 or 50% (Table 2). The annual earning was significantly lower in Houéyiho compared to the other sites (p=0.0001). About 28.93% of the farmers made less earning than the minimum wage in Benin. The coefficient of Gini was 0.4366 (Table 6). There was an uneven distribution of earnings. The earning gap between two exploitations chosen randomly could be as high as 400,644 XOF (801 USD). Moreover, farmers who focused exclusively on their farming activities had an average annual earnings of 1,019,000 XOF (2,038 USD) which is higher than the average earning of farmers who carried simultaneously other activities (817,300 XOF) (1,635 USD) (p=0.0222).

Table 6. Farmers' incomes (earnings) distribution

Income range (XOF)	Number	Percent	Annual income mean (XOF)	Monthly income mean (XOF)
<379500	57	28.93	238116.49	19843.04
[379500, 759000[	56	28.43	546850.54	45570.88
[759000, 1500000[	47	23.86	1026518.81	85543.23
[1500000, 3000000[	29	14.72	2006649.59	167220.80
>=3000000	8	4.06	3767593.75	313966.15
TOTAL	197	100	917646.00	76470.50
Gini Coefficient	0.4366			

.Characteristics and typology of farms

Most farmers work on small plots of land. The average size of farms was 1,341.55 m² (Table 2). A significant difference was observed in farms sizes depending on the sites (p=0.0001). The lowest average size was observed in Houéyiho (603.75 m ²) compared Sèmè-kpodji (2,478.75 m²) and Ouidah (1,861.64 m²). Approximately 3/10 of the farmers cultivated lands smaller than 500 m ² (Table 4). The others, 31.5% and 31% exploited surfaces ranging between 500 and 1000 m², and 1000 and 3000 m² respectively. More than 3/4 of the market-gardeners were farming on lands belonging to the National Community (Table 4). Almost all the farmers in Houéyiho (Cotonou) and Sèmè-kpodji were in such a situation. In Ouidah, 38.6% leased their farm lands from someone else and 54.5% were owners of their land.

With regard to labor, the main manpower used was relatives of the lead farmer (members of a same family). About half of the farms employed that type of labor. The producers also used temporary labor (44.2%) and paid labor (13.7%).

Results of the multiple correspondences analysis (MCA)

The method of multiple correspondences analysis (MCA) used made it possible to illustrate the main similarities and differences characterizing market-gardening farms. The factorial axes are indeed combinations of the terms structuring variables used in the analysis. Each axis can illustrate both associations and oppositions between terms. Certain terms are thus correlated positively with an axis while others are correlated with it negatively. The correlations analysis makes it possible to interpret the nature of these axes. Moreover, these axes are also characterized by the part of the total inertia of the individuals whom they represent, which provides an estimate of the quantity of information that each of them explain.

The first four axes of the analysis explain 26.88% of inertia, which is rather satisfactory given the high amount of indicators initially selected.

The first axis alone explains 10.15% of inertia. It characterizes the levels of resources endowments, the irrigation systems and the income earned from the exploitation. It can be interpreted as reflecting the opposition between:

- On one hand, the small farms whose owners cultivated surfaces less than 500 m² and producing local vegetables. They used less than 100 kg/year of NPK, less than 100 kg/year of urea, less than 5,000 kg/year of poultry manure and did not use bio-pesticides but spent 5,000 to 40,000 XOF/year (80 USD/year) for pesticides. They consumed less than 4,000 L of water per day; using the water of wells or shallows with a system of manual watering can with temporary labor and had a net income (earning) below 357,000 XOF/year (714 USD/year).

- On the other hand, medium size farms whose owners cultivated surfaces between 1,000 and 3,000 m² or more, producing local and exotic vegetables. These exploitations consumed between 100 and 500 kg/year or more of NPK and urea, more than 5,000 kg/year of poultry manure. The producers used bio-pesticides, but still spent more than 60,000 XOF/year (120 USD/year) in pesticides. They consumed

- more than 4,000 L of water per day. They used groundwater with motor-driven pumps systems and pipes and consumed fuel. The workforce was compensated labor and the net income of exploitation was above 1,785,000 Fcfa/year (3,570 USD/year).

The second axis explains 6.67% of inertia and characterizes the mode to put forward and the place of supply pesticide. It is interpreted as the opposition between:

- On one hand, farms whose producers cultivated on lands belonging to the public domain and supplying themselves in pesticides in shops in Cotonou.

- On the other hand, farms whose producers cultivated their own land or rented lands and obtained their pesticides supplies in Extension services.

The third axis explains 5.06% of inertia. It opposes:

- On one hand, farms whose producers did not belong to any farmers association didn't have the market-gardening as main activity and whose production had a low likelihood to continue in the long run.

- On the other hand the farms whose owners belong to a professional association and had market-gardening as principal activity and had a high likelihood to continue in the long run.

The fourth axis explains 5.00% of inertia. It is characterized by the socio-demographic situation of the owners and opposes:

- On one hand, the producers of 17 to 30 years of age, generally single and with less than 5 years of experience in market-gardening.

- On the other hand, the producers more than 30 years old, married and with more than 15 years of experience.

Categorization of the farms

Categorization sets up relatively homogeneous groups on the basis of variables used in the multiple correspondences analysis.

The most relevant grouping includes 7 categories, each one of them containing between 8.12% to 23.35% of farms (Figure 2).

Class 1: small-scale farming, manual watering, public domain, weak experience

With 12.7% of the farms, this category includes small farms (less than 500 m²), which consumed less than 2,000 L of water per day, more than 100 kg of urea and less than 3,000 kg of poultry manure per year. They didn't use any chemical fertilizer and relied on manual watering (with watering-can). The farmers were young with little experience. They joined farming through a more experienced relative. They mostly used public domain lands located in Houéyiho (Cotonou). These farmers had a little starting capital and mainly produced solanum, amaranth and lettuce. They used chemical pesticides. Their annual net income (earning) was below 357,000 XOF (714 USD) and the average return on investment was 38.87%. These farmers had little confidence about the long term prospects of their exploitation.

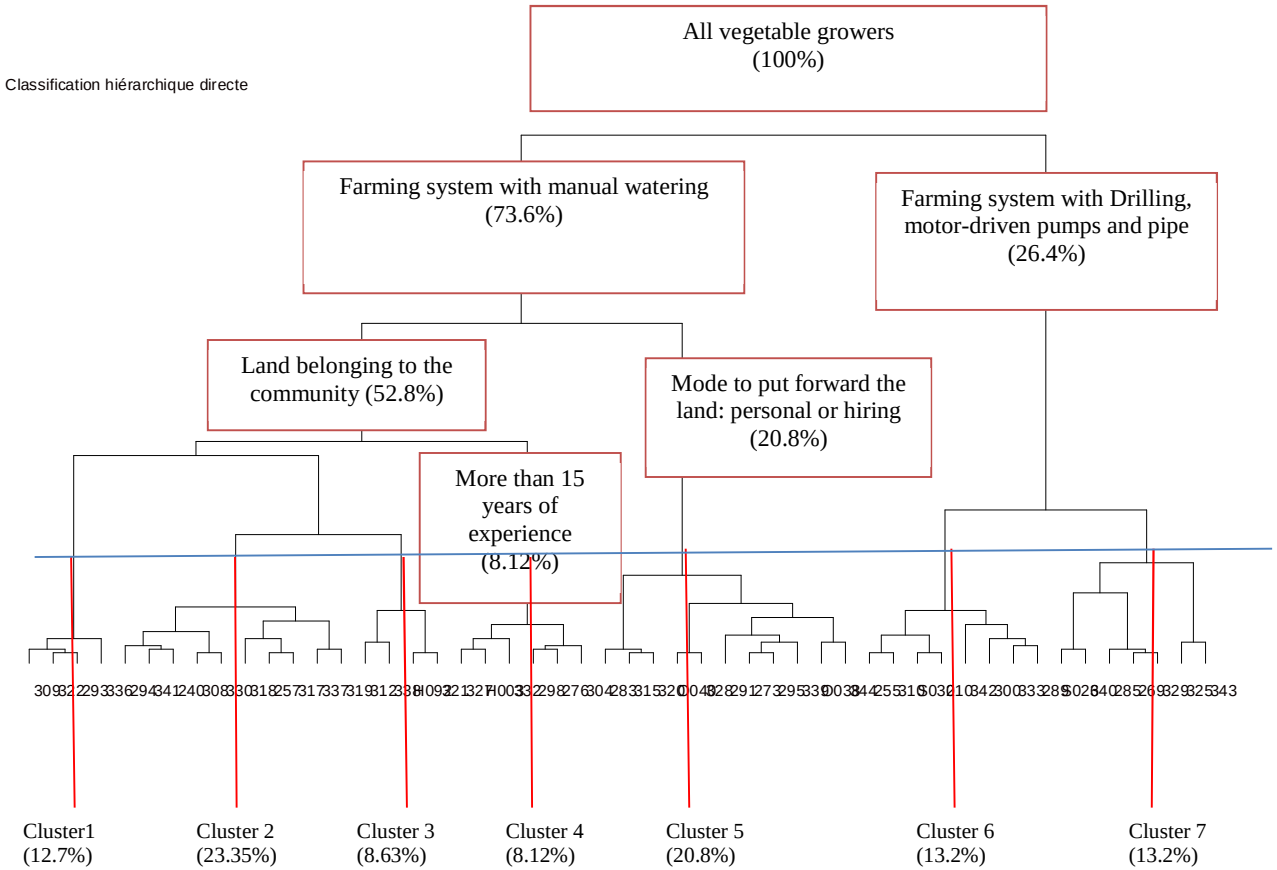

Fig 2. Typology of the market-gardening exploitations

Class 2: intermediate size farms, manual watering, public domain, weak or average experience
This category includes 23.35% of farms whose size range between 500 and 1000 m ². They consumed between 2,000 L and 4,000 L of water per day and had an annual net income from 357,000 to 714,000 XOF. They exploited public domain lands and produced any type of vegetables. They used less than 100 kg/year of chemical fertilizers (NPK and urea respectively), organic poultry manures and compost (less than 5,000 Kg/year). These farmers had less than 15 years of experience and no system of motorized irrigation. Market-gardening was their main activity. The average return on investment was 39.48%. The farmers were not absolutely confident about the continuation of their activities.

Class 3: large farms, manual watering, public domain, average experience
This category includes 8.63% of sample. Farms sizes range from 1,000 to 3,000 m². They consumed more than 4,000 L of water per day, used more than 300 kg per year of chemical fertilizer NPK and urea respectively, and more than 5,000 Kg of organic compost. The owners were knowledgeable about pests, adopted farming rotation, and spent more than 60,000 XOF/year in chemical pesticides. They did not however use biopesticides and did not have motorized irrigation systems. They used temporary labor for the manual watering and were predominantly located in Houéyiho. Gardening was their main source of income. Their annual net income was in the range of 714,000 XOF to 1,428,000 XOF and the return on investment was 39.42%. The farmers were confident about the continuation of their activities.

Class 4: large farms, manual watering, public domain, high experience
8.12% of the farms belong to this category. Their size was in the range of 1,000 to 3,000 m ². They consumed more than 500 kg of urea, more than 500 kg of NPK and more than 5,000kgs of organic poultry manures and compost. The farmers had in average, more than 15 years of professional experience. They were knowledgeable about pests, adopted farming rotation, but also spent more than 60,000 Fcfa/year on chemical and biological pesticides. They used family labor and a system of manual watering. They belonged to a farmers' association. Market-gardening was their exclusive income yielding activity. Their annual net income was between 714,000 XOF and 1,785,000 XOF and the average return on investment was of 42.22%. These farms didn't have any going concern issue.

Class 5: intermediate size farms, manual watering, private field, high experience
This category included 20.8% of the farms, whose size was below 2,000 m² and that suffered a lot of erosion. These farms were located in Ouidah. They consumed more than 150 kg of NPK and 300 kg of urea per year and more than 6,000 Kg/yearof organic poultry manure. The producers used very little compost of household waste. They were very experienced with gardening, used chemical pesticides but little biopesticides. They either farmed their own land or rented from particulars. They barely adopted farming rotation techniques, took water from well for their irrigation. Most of them belonged to farmers' associations. Gardening was their main activity and brought them an annual average net income of 714,000 to 1,428,000 XOF which corresponds to an average return on investment rate of 41.88%. The continuation of these exploitations was deemed certain by most of these farmers.

Class 6: intermediate size farms, motorized watering, public domain, weak experience
This category includes 13.2% of the farms with sizes ranging between 1,250 and 2,500 m ² and an annual consumption of more than 500 kg for urea and NPK respectively, and more than 5,000Kg for organic manures poultry manure and compost. The farmers had between 1 and 5 years of experience, and generally lived on the site of their exploitation. They went through a 18 months training before starting. Most of them undertook at least three years of secondary studies. They were knowledgeable about pests and adopted farming rotation. They used both chemical and biological pesticides for pests control. Their annual pesticides expenditures sometimes exceeded 60,000 XOF/year. They used a motorized apparatus that consumed less than 2L per day of gasoline and more than 4,000 L of water per day. The farmers used public domain lands in Sèmè-kpodji or Cotonou. Market-gardening was their sole economic activity. Their annual net income ranged from 1,071,000 XOF to 1,785,000 XOF and the average return on investment was of 46.22%. Most of the farmers had no going-concern issue, but highlighted land availability as their main potential threat.

Class 7: large farms, motorized watering system, public domain, high experience
This category also included 13.2% of the farms with sizes ranging between 2,500 and 5,000 m², consumed more than 500 kg of urea and NPK respectively and more than 5,000Kg of organic poultry manures and compost. The farmers used a motorized apparatus that consumed more than 2L/day of fuel and employed paid labor. They were very experienced in the gardening field and were knowledgeable about pests. They widely adopted farming rotation, used both chemical pesticides and bio-pesticides. They spent more than 60,000 XOF/year for pesticides. These farms were located in Houéyiho or Sèmè-kpodji with annual net income above 1,785,000 XOF/year and average return on investment of 51.90%. Some of these farmers used protection gears before spreading pesticides. No going concern issue was indicated.

DISCUSSIONS
Most of the farmers did not have a high educational level and exploited small plots of land for their production. Farm sizes were smaller in Houéyiho because of urbanization constraints and limited land availability, Cotonou being the main city of the country. They used land belonging to the public domain. The majority of the producers were full-time farmers. These results confirm those of Broutin *et al*. (2005). The authors reported market-gardening as the principal source of income for 85.23% of the farmers surveyed and the only source of income for 34.09% of them. The average experience was 14.36 years. This can be explained by the fact that many young people learn gardening with their parents and embrace that career due to the high unemployment or after dropping out of school. The farmers in Houéyiho in Cotonou were more experienced than those in Sèmè-kpodji and Ouidah. Houéyiho is one of the oldest market-gardening site in the country; it was established forty years ago.

Overall, the production was characterized by weak farming rotations, the use of chemical and organic fertilizers as well as a widespread use of chemical pesticides for pests and diseases control. Indeed the major constraint of this activity is the attack of pests and germs induced diseases, the other constraints were irrigation problems, soils fertility, markets, lands availability and the access to production inputs. Akogbéto *et al*. (2005) reported a dependence of the Beninese periurban market-gardening to the use of chemical pesticides. Similar observations were also made in market-gardening production in rural environment in Tori-Bossito in Benin (Ahouangninou *et al*., 2011). Research by Obopile *et al*. (2008) in Botswana on the analysis of farmers' perceptions in regards to pests and diseases control reported that the chemical pesticides were critical for them. Most gardeners couldn't conceive of gardening without chemical pesticides. Chemical pesticides use affects vegetables quality (Ahouangninou et al., 2013), human health (Ton et al., 2000) and the environment. The environmental consequences of the use of pesticides in Benin were documented in a study by Pazou *et al*. (2006a, 2006b). According to the growers, the biopesticides available on the market: LASER 480 SC (Spinosad 480 g/L) and BIOBIT (Bacillus thuringiensis) do not eliminate all the pests. Biopesticides are less harmful for agro-ecosystems and decrease the risk of presence of residues in harvested vegetables. However, some of them have a slower action, require a specific environment to be effective or have side-effects. (Birch *et al.*, 2011). According to the farmers, their production would not be competitive on the market without the use of chemical pesticides. Moreover, the production is for local market and most of the local consumers are less aware of and less sensitive about the chemical quality of the vegetables they consume. According to the farmers, these consumers were very price-sensitive and were not willing to pay more to have organically grown vegetables. This was also reported in other cities in West Africa. The consumers in Thiès (Senegal) never used the production methods as criteria in their assessment of quality (Broutin *et al*., 2005). But researches conducted by Coulibaly *et al*. (2011) reported that the consumers of cabbages and tomatoes in Benin and in Ghana were willing to pay a premium of more than 50% to have vegetables produced without chemical pesticides. According to that study, consumers' selection criteria were harmlessness of the product, its color, its weight and its freshness.

Market-gardening in Southern Benin consumes both chemical fertilizers (urea, NPK) and organic fertilizers (poultry manures and compost of domestic solid waste). All the seven categories of market-gardening farms use chemical and organic fertilizers. The farms of category 1 consumed neither NPK nor compost. Those of category 5 used a very small amount of compost. Brock and Foeken (2006) reported that market-gardening plays an important role for the recycling of solid waste in urbanized areas in Benin. The consumed levels of organic manures are comparable with those of the market-gardeners of northern-Benin implied in the approach FFS (Farmer Field School) whose levels of organic manure used increased by 481% (Settle and Garba, 2011). The use of poultry manure and compost is an efficient waste disposal method and can reduce production costs

and environmental pollution due to chemical fertilizer consumption. This is a strong point for market-gardening sustainability in southern-Benin. But producers of categories 1 and 4 overused chemical fertilizers (urea and NPK). The average amount of organic poultry manure applied to *Solanum macrocarpon*, in southern Benin was overall in conformity with the standards. The amount of chemical fertilizers (urea) used was on average 333.33 Kg/ha. This is much higher than the recommended norms: 75 to 150 Kg/ha (INRAB, 2006). These findings are in conformity with those of Assogba-Komlan *et al*. (2007) who concludes that urea is overused in the production of *Solanum macrocarpon* in Southern Benin.

The watering of seedlings is a burdensome task that along with tillage and sowing, make gardening a painful activity. Market-gardening is very water-intensive. The market-gardener must sprinkle twice a day to ensure that the seedlings have enough water. This requires a lot of manpower. A few can afford a motorized irrigation system to reduce the pain of work, their labor costs and production costs in general. Farmers in categories 6 and 7 adopted this type of irrigation. Motorized irrigation was more frequent in Sèmè-kpodji. This could be explained by the fact that most of the producers on that site are young and new to the profession. These young producers were trained with news techniques and tools and are more likely to adopt new technologies. The average gasoline consumption was significantly higher in Ouidah. This could result from the combination of two factors: the type of soils and the fact that groundwater is very deep in certain districts of Ouidah. Farms that use a motorized system tend to have a higher annual income than those that don't. If on one hand, the use of the motorized systems reduces the painfulness of work and the production costs; on the other, it is also polluting, because it releases gases with greenhouse effect and can negatively impact the environment. Several specimens (both local and exotic) of vegetables were produced. These specimens were sold on markets in the main cities. From the producers to the final consumers, they are few intermediaries. The farmers sell most of their harvest to retailers (women mainly) who sell them directly to the consumers. Very few wholesalers or traders intervene in the supply chain. Broutin *et al*. (2005) reported that the distribution chains in market-gardening in Senegal are often short (direct sales or only one intermediary).

According to Moustier (1997), periurban agriculture in Africa plays an essential role for food safety and employment instead of being leisure or a landscaping tool. The annual average income is 917,646 XOF per farmer in 2009, so about 76,470.5 XOF per month for each producer. This is 2.42 times the minimum wage in Benin (currently 31,625 XOF per month since March 25th, 2009). The significant differences observed in earnings among the various production sites could be related to the small size of farms in Houéyiho (Cotonou). Farms in categories 1, 2 and 5 were small in size. This made it hard for to make significant profits. These results are in conformity with those of Tokannou and Quenum (2007) who reported that the availability of lands in Cotonou is very limited and even insufficient to let the farmers make a decent living. However, larger farms (categories 4, 6 and 7), made more money. More than a quarter of the farmers made less than minimum wage. This group is dominated by people who did not have market-gardening as principal activity but combine it with other income-generating activities such as livestock farming and taxi-motorbike driving. Market-gardening also allows women to market fresh vegetables, sell them for profits to consumers, and use the proceeds to care for their children. According to Tokannou and Quenum (2007), market-gardeners often come from a poor social background. The annual earnings are comparable to those reported by Lemay-Boucher and Dagnelie (2012) among inhabitants of three poor districts of Cotonou. A project of improvement of the production and income of the producers could target the first five categories of market-gardeners who experience more hardship (difficult access to land, challenges with irrigation and pests and diseases control). A follow-up program for the acquisition of systems of motorized irrigation could help these farmers increase their productivity and their income (Atidégla, 2006). Also, it will be appropriate to educate these farmers about the adoption of the biopesticides. This has the potential of improving the environmental impact of this activity. Farms categories 6 and 7 include the producers who exploit larger farming areas with a motorized irrigation system and use both chemical pesticides and biopesticides. These farmers earned sufficient income from their production. Motorized systems are also polluting because they consume fossils fuels and release gases with greenhouse effect. A system of motorized watering using renewable energies such as solar energy or the wind energy would ensure the ecological sustainability of the production. The municipal authorities must add market-gardening production activity to their priorities. They must guarantee the sustainability of this activity by allocating lands to farmers especially those of Cotonou and Sèmè-kpodji who are threatened of eviction because they are occupying lands belonging to the national community (Brock and Foeken, 2006; Tokannou and Quenum, 2007). The producers of Sèmè-kpodji are especially threatened by the construction project of a new port. This insertion of market-

gardening on the municipal or communal agendas could safeguard the livelihood of an important fringe of the active population (current producers and graduates without employment). The municipalities could also encourage farmers to contribute to the financings of the infrastructures by imposing contractual sums to them.

CONCLUSION

Through this study, we characterized the urban and periurban market-gardening activity conducted on the production sites of Cotonou, Sèmè-kpodji and Ouidah and identified the typology of the farms as well as the constraints they face. Market-gardening constitutes the principal activity for most of the producers and generates incomes allowing them to provide for their household needs. It also generates incomes for the retailers. In spite of its economic and social value, the sector has some going concern issues. Thus to ensure the sustainability of this activity, the municipal or communal authorities must insert it in their priority action plans and take action in order to safeguard the livelihood of an important fringe of the active population. Extension service's action is also need to improve the productivity and the environmental impact of this activity.

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